



UNIVERSITI PUTRA MALAYSIA

**EFFECTS OF COGNITIVE STRESS ON THE
TEMPORAL ANTICIPATION OF A TIMING MOTOR TASK**

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By

PATHMANATHAN K.SUPPIAH

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Master of Science**

November 2003



Abstract of thesis presented to the Senate of University Putra Malaysia
in fulfilment of the requirements for the degree of Master of Science

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Chairman: Mohd. Khairi bin Zawi, Ph. D

Faculty: Educational Studies

The study was designed to investigate the effects of cognitive stress on the temporal anticipation of a timing motor task. The experimental design applied was a repeated measures design with two independent variables (cognitive stress and levels of difficulty – easy, intermediate and difficult). The participants of this study consist of 18 male and 19 female undergraduates of the Physical Education programme of University Putra Malaysia. The participants were required to perform a timing motor across three levels of difficulty and under two conditions i.e. without cognitive stress and under cognitive stress. Cognitive stress was induced via the continuous subtraction of two from a two-digit number. Participants performed the task individually and the sequence of the experimental task was counter-balanced.

A two-way within subject's ANOVA was performed to ascertain the effects of cognitive stress on the temporal anticipation of the timing motor

task. The data analysis revealed a significant difference in means for the stress main effect ($\Lambda = .64$, $F(1.35) = 19.89$, $p = .00$); and the task main effect ($\Lambda = .84$, $F(2, 34) = 3.35$, $p < .05$). Post hoc comparisons produced a significant difference in the means of the performance of the timing motor task at all three levels of difficulty. This showed that cognitive stress had an effect on the temporal anticipation of the timing motor task.

A two way mixed design ANOVA was conducted was performed to ascertain the effects of cognitive stress on the temporal anticipation of the timing motor task with regard to gender. The task main effect was significant ($\Lambda = .59$, $F(5,170) = 6.70$, $p = .01$). Follow up comparisons revealed significant difference in the performance of the experimental task at the easy level without cognitive stress, intermediate level without cognitive stress and the easy level under cognitive stress. This showed that there was a significant difference in the performance of the timing motor at the three levels mentioned.

These results are explained from attentional perspectives and the neuromotor noise perspective. It was concluded that the significant difference in the performance of the experimental task was due to the competition for attentional resources and the decrease of the signal to noise ratio due to cognitive stress.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

**KESAN STRES KOGNITIF KE ATAS ANTISIPASI TEMPORAL
SATU LAKUAN MOTOR *TIMING***

Oleh

PATHMANATHAN K.SUPPIAH

November 2003

Pengerusi: Mohd. Khairi bin Zawi, Ph.D

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Kajian ini telah dijalankan untuk menyelidik kesan stres kognitif ke atas antisipasi temporal satu lakuan motor. Kaedah yang diaplikasikan adalah kaedah eksperimental dengan pengukuran berulang dengan dua pembolehubah bebas (stres kognitif dan tahap kesukaran – mudah, sederhana dan sukar). Peserta-peserta kajian (lelaki = 18 & wanita = 18) terdiri daripada siswazah program Bachelo Pendidikan Jasmani, Universiti Putra Malaysia. Peserta kajian perlu melakukan satu lakuan motor *timing* (tugasan primer) pada tiga tahap kesukaran di bawah dua keadaan iaitu tanpa stres kognitif dan di bawah stres kognitif. Tugasan sekunder, yang menghasilkan stres kognitif, memerlukan peserta kajian melakukan pengurangan berurutan satu angka dua digit dengan dua. Peserta-peserta kajian melakukan tugas eksperimental secara individu dan urutan tahap kesukaran diimbang balik (counter balanced).

Penganalisaan statistik (two-way within subject's ANOVA) telah dijalankan ke atas data yang diperolehi dari lakuan tugas eksperimental. Hasil penganalisaan menunjukkan perbezaan signifikan untuk kesan utama stres ($\Lambda = .64$, $F(1,35) = 19.89$, $p = .00$). Perbezaan yang signifikan juga diperolehi untuk kesan utama tugas ($\Lambda = .84$, $F(2, 34) = 3.35$, $p < .05$). Perbandingan *post-hoc* menghasilkan perbezaan yang signifikan untuk ketiga-tiga tahap kesukaran lakuan motor *timing*. Ini menunjukkan stres kognitif mempunyai kesan ke atas lakuan motor timing yang memerlukan antisipasi temporal.

Analisis *two way mixed design ANOVA* dilakukan untuk mengenalpasti perbezaan pencapaian peserta berdasarkan jantina. Kesan utama tugas didapati signifikan ($\Lambda = .585$, $F(5,170) = 6.70$, $p = .01$). Perbandingan *post-hoc* mendapati perbezaan yang signifikan adalah untuk pencapaian peserta pada tahap mudah tanpa stres kognitif, tahap sederhana tanpa stres kognitif dan pada tahap mudah di bawah stres kognitif. Ini menunjukkan stres kognitif mempunyai kesan ke atas lakuan motor timing yang memerlukan antisipasi temporal pada ketiga-tiga tahap lakuan motor *timing* yang disebutkan.

Dapatan kajian dibincangkan mengikut perspektif tumpuan dan perspektif neuromotor. Kesimpulan kajian ini adalah perbezaan yang signifikan dalam pencapaian peserta dalam tugas eksperimental adalah hasil daripada saingan untuk sumber tumpuan dan pengurangan nisbah isyarat ke kebisingan yang dihasilkan oleh stres kognitif.

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I certify that an Examination Committee met on 18 November 2003 to conduct the final examination of Pathmanathan K. Suppiah on his Master of Science thesis entitled "Effects of Cognitive Stress on the Temporal Anticipation of a Timing Motor Task" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. The Members of the Examination Committee are as follows:

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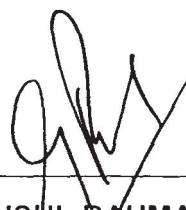
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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.


PATHMANATHAN K. SUPPIAH
Date: 30/12/2003

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CHAPTER 1

INTRODUCTION

The emphasis in this introductory chapter is based upon the premise that human are processors of information. This information, in the form of environmental stimuli is evaluated and consequently used to plan their movements in advance. The inability of performers to produce optimum levels of performances under stress is discussed.

Anticipation in Movement

Anticipation is an integral part of response elicitation in fast paced movement settings. It requires an individual to use available cues in the environment to plan and carry out goal-orientated movements. Anticipation is essentially a strategy applied by individuals to prepare a motor response in advance. In sports settings, there are a number of situations where attempts are made to either prevent or enhance anticipation. In athletic sprint events, starters vary the interval between the “set” command and the firing of the pistol. The variance of this interval (foreperiod) prevents the athletes involved from anticipating the start of the race. In other situations, team players communicate with one another, enabling their teammates to plan their actions in advance. For example, in baseball the catcher signals the pitcher for confirmation of the type of pitch that the pitcher is about to execute. In this situation, the catcher is able to plan and consequently

execute an accurate response. The role of anticipation in the production of an accurate response is solely governed by the timing module of human motor control.

Anticipation is defined as the ability of the performer to plan his or her movement in advance based upon the movement of the object of his actions (Magill, 1993). This ability can be divided into two subcomponents: (i) spatial anticipation, and (ii) temporal anticipation. Spatial anticipation is defined as the ability to 'guess' the location of the stimulus or the movement that has to be produced (Schmidt, 1988). A hockey goalkeeper whose view is blocked by outfield players would not be able to see the complete trajectory of the hockey ball as it heads towards his goalmouth. The hockey goalkeeper would have to determine the final location of the hockey ball based on cues that appear intermittently. Concurrently, the hockey goalkeeper has to produce a reaction that would prevent the hockey ball from entering his goalmouth and consequently give an advantage to the opposition. The production of an interceptive movement would require the hockey goalkeeper to not only predict where the ball will be but also when the ball would be at the anticipated location.

The ability to determine the location of the ball temporally is referred to as temporal anticipation (Schmidt, 1988). Temporal anticipation does not only include the prediction when the stimulus would appear but also the timing of the movement that has to be produced to meet the objective of a given movement. The above example illustrates the importance of timing

modularity in anticipation and the temporal constraints within which relevant cues become available for the anticipatory process.

The ability to anticipate accurately is dependent on the amount of information and time available to the performer. On the other hand, the accuracy of the response produced by the performer is dependent upon the ability to process the available cues within the temporal constraints. Precise timing of response necessitates attunement to these available cues; a mechanism that imposes high attentional demands. Hence, attention plays a vital role, as it is the focus of attention that enables the performer to isolate the relevant cues from the array of cues that are available within the performing environment.

Attention

Early theories of attention (Welford, 1952; Broadbent, 1958; Norman, 1969; Norman and Keele, 1963) have proposed that information about the environment is 'filtered' at various stages of the human information-processing system. The function of these filters are to exclude irrelevant information (e.g. jeering spectators) from the environment and allowing only information, that is relevant (e.g. the spin of a pitched baseball) to the selection and programming of an appropriate response, to be processed. This view on attention proposes a serial processing of information from the environment.

Neuman (1987) disputed the view that attention requires some kind of capacity to function and attributes that decrements in performance are due to attentional demands exceeding the capacity available for attention. This view proposed that reception and processing of stimuli occurs in a parallel manner. The final act of such parallel processing is the selection of an appropriate response. Once a response is selected, all other processes are blocked or occur with great difficulty. Detriments in performance are due to a selected response being processed thus blocking or hindering the process of other responses. In other words, selection of a response is the basic or fundamental process of attention.

An alternative view that proposed attention as a flexible allocation capacity was proposed by Kahneman (1973). According to Kahneman, attention has a flexible capacity that fluctuates according to the level of arousal of the performer. This flexible capacity of attention is divided to the relevant stimulus and processed based on the demands of the performance. This view also proposes that a performer whose level of arousal is too high would have a 'smaller capacity' of attention compared to a performer whose level of arousal is optimal. When attention requirements exceed the available attentional capacity, decrements in performance are bound to occur. This view also proposes that processing can occur in parallel if the available attentional capacity is able to process the information needed for the successful completion of the task or tasks. A psychological theory that adds credence to this view is the Zone of Optimal Functioning (ZOF) (Hanin, 1980). According to this hypothesis, each individual possesses a zone

defining a range of arousal levels within which the individual's performance is optimised. In addition, zones of optimal functioning differ from one individual to the next and are task and environment specific. A performer who is within his or her ZOF would be able to produce optimum performances.

Attention has also been viewed as multiple cognitive resources (McLeod, 1980). Each of these resources has their own capacity and each resource handles the information processing for a specific activity. For an example, different pools of cognitive resources handle attention demands for upper limb and lower limb movements.

Cognitive factors, such as attention, play an important role in the performance of sports skills (Jones & Hardy, 1980). Performances of sports skills are not only dependent on physiological factors (e.g. strength and endurance) and biomechanical factors (e.g. technical aspects) but also dependent on the cognitive ability of the performer. Orlick and Parlington (1988) propose that, of the three factors (i.e. mental, physical and technical) that play a role in athlete preparation, mental readiness plays the most important role in determining the level of performance shown by the athlete during competition. Most athletes are unable to produce their best performances due to interferences that affect their attention to cues that are relevant to their response setting. These interferences which may appear in various forms such as cheering or jeering spectators, personal goals or aspirations may lead to conditions of stress.

Stress and Performance

Stress generally refers to a state of increased heart rate, perspiration, dilated pupils and high alertness. Both external factors (e.g. spectators) and internal factors (e.g. stress) contribute to the level of arousal experienced by a performer. Arousal refers to the range between sleep and a high level of alertness (Martens, 1977). These factors (i.e. external and internal) determine the internal equilibrium of the athlete and consequently affect the level of performance produced. Internal equilibrium refers to the state of calmness experienced by an individual without the feel of demands both mentally and physically.

Stress is a result of a physical, biological and/or psychological situational response to a stressor that burdens an organism beyond its coping ability (Bull, 1995). An individual will be compelled to use his mental and physical reserves to match and overcome the stressors. Failure to meet the demands will lead to a decrement in performance (Bar-Eli & Tenenbaum, 1988). An 'interactionist' perspective on stress defines stress as environmental stimuli that are demanding or burdensome (Bull, 1995). This perspective also illustrates stress as the emotional response due to the interaction of the individual with the environment. An individual's evaluation of the environment determines the response. If a performer views an impending competition as difficult, the competition will be viewed as a burden eliciting an anxiety like response. In the event of the competition not

perceived as burdensome (a familiar opponent that has been defeated), the performer would not be affected by this phenomenon.

Studies on the effects of stress on performance have categorised stress into three classes, emotional, physical and cognitive. Studies on the effects of emotional stress on performance have shown that worry and emotional control as personality traits have negative effects on a dart throwing performance (Adam & Werringen, 1988). Physical stress (in the form of loud noises) does not contribute to decrement in performance of a space orientation task. Cognitive stress, on the other hand, has a negative effect on a similar space orientation task. The coordination of various daily tasks increases the demands on cognitive resources that in turn are stressful to individuals (Castiello & Umilita, 1988).

Nideffer (1981) proposed that if demands on cognitive resources proceed beyond the coping ability of the performer, the focusing of attention suffers. Nideffer contends that attentional focus narrows or widens due to stress. An overly narrow focus of attention would lead to the omission of task relevant cues and on the other hand, an overly wide focus of attention would lead to the unnecessary processing of irrelevant cues.

A concept closely related to attention and the performance of multiple tasks is mental workload. This concept refers to the resource demands on a performer (Proctor & Dutta, 1995). Performance deteriorates when the resource demands of a task are too high or too low. In the case of resource

demands of a task being too high, performance deterioration is attributed to the stressful condition experienced by the performer. On the other hand, resource demands that are too low cause boredom to performers that leads to poor performance. The dual task is viewed as a burden on cognitive resources that would lead to a decrement in performance of a temporal anticipation task.

Based on the Information Processing Model, the production of an accurate motor response is dependent upon the identification and processing of relevant cues from the performing environment. The performance of tasks that require temporal anticipation involves the coordination of multifaceted task aspects. A performer needs to coordinate one's own movement in concert with the trajectory of the object that is to be anticipated. The irregular flight path of the object due to various factors (e.g. spin) increases the amount of information that needs to be processed. The coordination of these aspects leads to an increase in mental load and therefore may result in a state of cognitive stress.

Statement of the Problem

The production of an anticipatory response is largely dependent upon the identification and processing of task relevant cues. For example, in determining the nature of ball flight, the performer has to identify the trajectory of the object of the task, based on the movement characteristics (e.g. spin and velocity) of the object. The ability of the performer to focus

one's attention on these pertinent cues is dependent on the internal emotions (e.g. anxiety) and externally induced pressures (e.g. successful performance of task).

These simultaneous processing of task relevant information, internal emotions and external pressures increases the mental workload of the performer, which in turn leads to conditions of cognitive stress. Thus, it is relevant to determine the extent cognitive stress may effect the temporal anticipation of a timing motor task. It is further necessary to determine whether the level of task difficulty and gender are critical variables that influence the temporal anticipation of a timing motor task under cognitive stress.

Research Objective

Studies conducted on the effects of cognitive stress on performance to date, have only focussed on the outcome of a motor task. By adopting a modular approach in accounting for human motor-control mechanisms, it is the purpose of this study to isolate the effects of cognitive stress on a component of a discrete motor task. The objective of this study is:

1. to determine the effects of cognitive stress on the temporal anticipation of a timing motor task.

2. to investigate the effects of different levels of difficulty on the temporal anticipation of a timing motor task performed without cognitive stress and the temporal anticipation of a timing motor task performed under cognitive stress.
3. to investigate the influence of gender on the temporal anticipation of a timing motor task performed without cognitive stress and the temporal anticipation of a timing motor task performed under cognitive stress.

Significance of the Study

The ability of humans to produce peak motor performances is dependent on the psychological state of the individual. There exists a wide range of factors, referred to as 'stressors', which can influence the alteration of the individual's psychological state to a level that is out of the optimum range required for a particular type of performance.

In movement settings, specifically sports, situational stressors like competition impose cognitive demands on the performer, which may affect the level of performance. It is imperative that the effects of these stressors on performance are accounted for so that psychological strategies to assist optimum performance can be explicated.